

FORM PTO-1390
(REV 10-94)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

9320.116USWO

U.S. APPLICATION NO. (If known, enter 35 U.S.C. 371(f))
Unknown 09/743972

INTERNATIONAL APPLICATION NO.

PCT/FR99/01924

INTERNATIONAL FILING DATE

August 3, 1999

PRIORITY DATE CLAIMED

August 3, 1998

TITLE OF INVENTION

SELECTIVE MESH REFINEMENT

APPLICANT(S) FOR DO/EO/US

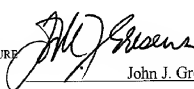
GIOIA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An unsigned oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
☐ A SECOND of SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Preliminary Examination Report; International Search Report; 1449 and cited references; front page of PCT application

U.S. APPLICATION NO. (If known, see 37 CFR 1.5) Unknown		INTERNATIONAL APPLICATION NO. PCT/FR99/01924		ATTORNEY'S DOCKET NUMBER 9320.116USWO	
17. [X] The following fees are submitted:				CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492(a) (1)-(5)): Search Report has been prepared by the EPO or JPO.....\$860.00 International preliminary examination fee paid to USPTO (37 CFR 1.492(a)(1))\$720.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2))\$790.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(3)) paid to USPTO\$1,000.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)\$98.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$860.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$0	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	8 -20 = 0		X \$18.00	\$0	
Independent claims	1 -3 = 0		X \$80.00	\$0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$260.00	\$0	
TOTAL OF ABOVE CALCULATIONS =				\$860.00	
Reduction by 1/2 for filing by small entity, if applicable. Small entity status is claimed pursuant to 37 CFR 1.27				\$0	
SUBTOTAL =				\$860.00	
Processing fee of \$130.00 for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				+ \$0	
TOTAL NATIONAL FEE =				\$860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				+ \$0	
TOTAL FEES ENCLOSED =				\$860.00	
				Amount to be: refunded \$0	
				charged \$0	
a. [X] Check(s) in the amount of \$860.00 to cover the above fees is enclosed. b. [] Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed. c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>13-2725</u> .					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO John J. Gresens MERCHANT & GOULD P.O. Box 2903 Minneapolis, MN 55402-0903					
				SIGNATURE	
				NAME	John J. Gresens
				REGISTRATION NUMBER	33,112

09/743972

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: GIOIA
 Docket: 9320.116USWO
 Title: SELECTIVE MESH REFINEMENT

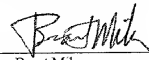
JC06 Rec'd PCT/PTO 17 JAN 2001

CERTIFICATE UNDER 37 CFR 1.10

'Express Mail' mailing label number: EL658339301US

Date of Deposit: January 17, 2001

I hereby certify that this paper or fee is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

By: 
 Name: Brant Miles

BOX PATENT APPLICATION
 Assistant Commissioner for Patents
 Washington, D.C. 20231

Sir:

We are transmitting herewith the attached:

- ☒ Transmittal sheet, in duplicate, containing Certificate under 37 CFR 1.10.
- ☒ National Stage PCT Patent Application: Spec. 11 pgs; 8 claims; Abstract 1 pg.
The fee has been calculated as shown below in the 'Claims as Filed' table.
- ☒ 2 sheets of formal drawings
- ☒ An unsigned Combined Declaration and Power of Attorney
- ☒ A check in the amount of \$860.00 to cover the Filing Fee
- ☒ Other: PTO-1390; Preliminary Amendment; International Preliminary Examination Report; International Search Report; Front page of PCT application;
- ☒ Return postcard


CLAIMS AS FILED

Number of Claims Filed	In Excess of:	Number Extra	Rate	Fee
Basic Filing Fee				\$860.00
Total Claims				
8	- 20	= 0	x 18.00	= \$0.00
Independent Claims				
1	- 3	= 0	x 80.00	= \$0.00
MULTIPLE DEPENDENT CLAIM FEE				\$0.00
TOTAL FILING FEE				\$860.00

Please charge any additional fees or credit overpayment to Deposit Account No. 13-2725. A duplicate of this sheet is enclosed.

MERCHANT & GOULD P.C.

P.O. Box 2903, Minneapolis, MN 55402-0903
 (612) 332-5300

By: 
 Name: John J. Gresens
 Reg. No.: 33,112
 Initials: JJG/tvm



23552

PATENT TRADEMARK OFFICE

(PTO TRANSMITTAL - NEW FILING)

S/N unknown

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	GIOIA	Docket No.:	9320.116USWO
Serial No.:	unknown	Filed:	concurrent herewith
Int'l Appln No.:	PCT/FR99/01924	Int'l Filing Date:	August 3, 1999
Title:	SELECTIVE MESH REFINEMENT		

CERTIFICATE UNDER 37 CFR 1.10

'Express Mail' mailing label number: EL658339301US

Date of Deposit: January 17, 2001

I hereby certify that this correspondence is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

By: 

Name: Brant Miles

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendment (marked-up copy attached):

IN THE ABSTRACT

Insert the attached Abstract page into the application as the last page thereof.

IN THE SPECIFICATION

A courtesy copy of the present specification is enclosed herewith. However, the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

IN THE CLAIMS

Please amend the following claims:

3. (Amended) Encoding method according to claim 1, characterized in that it enables access to several levels of encoding quality, corresponding to each of said successive meshes.

4. (Amended) Encoding method according to claim 1, characterized in that said successive meshes are obtained by the implementation of a recursive algorithm.

5. (Amended) Encoding method according to claim 1, characterized in that said recursive algorithm comprises the following steps:

- (a) the reception (31) of a wavelet coefficient indexed by a vertex (s) of barycentric coordinates (α, β, γ) on a face F_0 ;
- (b) for each neighboring face F_j of F_0 containing said vertices (s):
 - $F = F_i$ is supposed;
 - from the barycentric coordinates (α, β, γ) , the coordinates of said vertex (s) in the refined base (42) formed by the vertices of the face F, also referenced (α, β, γ) are deduced;
 - if the coordinates α , β or γ are positive or zero and if two of them are strictly positive (43):
 - the face F (45) is subdivided;
 - the processing of the step (b) is resumed for the four offspring of the face F successively

8. (Amended) Application of the encoding method according to claim 1 to at least one of the following fields:

- the display of meshed objects in a 3D screen;
- the progressive display of meshed objects in three dimensions on a screen, said wavelet coefficients being taken into account as and when they arrive;
- the display of meshed objects in three dimensions on a screen with at least two levels of detail, one level of detail corresponding to one of said successive meshes (M_i);
- the display of different parts of a meshed object with at least two different levels of detail;
- the compression of a mesh of a meshed object.

REMARKS

The above preliminary amendment is made to remove multiple dependencies from claims 3, 4, 5 and 8.

A new abstract page is supplied to conform to that appearing on the publication page of the WIPO application, but the new Abstract is typed on a separate page as required by U.S. practice.

Applicants respectfully request that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

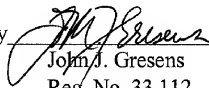
If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, John J. Gresens (Reg. No. 33,112), at (612) 371.5265.

Respectfully submitted,

MERCHANT & GOULD P.C.
P.O. Box 2903
Minneapolis, Minnesota 55402-0903
(612) 332-5300

Dated: January 17, 2001

By


John J. Gresens
Reg. No. 33,112

JJG/tvm

ABSTRACT

Title: SELECTIVE MESH REFINEMENT

The invention concerns a method for coding an original mesh representing a three-dimensional object, which consist in determining a simple meshing having a reduced number of defined faces each defined by vertices and edges, then coefficients in a wavelet base of a function whereof said source mesh is the image defined on said simple mesh, so as to supply successive refined meshes. The method is characterized in that each of the faces of said meshes is subdivided into a limited number of facets to form the higher level mesh, the subdivisions of said surface corresponding only to those required for observing an affinity condition of said function of said face. The invention also concerns the corresponding method for reconstructing the mesh.

FIG. 1
FIG. 2
FIG. 3
FIG. 4
FIG. 5
FIG. 6
FIG. 7
FIG. 8
FIG. 9
FIG. 10
FIG. 11
FIG. 12
FIG. 13
FIG. 14
FIG. 15
FIG. 16
FIG. 17
FIG. 18
FIG. 19
FIG. 20
FIG. 21
FIG. 22
FIG. 23
FIG. 24
FIG. 25
FIG. 26
FIG. 27
FIG. 28
FIG. 29
FIG. 30
FIG. 31
FIG. 32
FIG. 33
FIG. 34
FIG. 35
FIG. 36
FIG. 37
FIG. 38
FIG. 39
FIG. 40
FIG. 41
FIG. 42
FIG. 43
FIG. 44
FIG. 45
FIG. 46
FIG. 47
FIG. 48
FIG. 49
FIG. 50
FIG. 51
FIG. 52
FIG. 53
FIG. 54
FIG. 55
FIG. 56
FIG. 57
FIG. 58
FIG. 59
FIG. 60
FIG. 61
FIG. 62
FIG. 63
FIG. 64
FIG. 65
FIG. 66
FIG. 67
FIG. 68
FIG. 69
FIG. 70
FIG. 71
FIG. 72
FIG. 73
FIG. 74
FIG. 75
FIG. 76
FIG. 77
FIG. 78
FIG. 79
FIG. 80
FIG. 81
FIG. 82
FIG. 83
FIG. 84
FIG. 85
FIG. 86
FIG. 87
FIG. 88
FIG. 89
FIG. 90
FIG. 91
FIG. 92
FIG. 93
FIG. 94
FIG. 95
FIG. 96
FIG. 97
FIG. 98
FIG. 99
FIG. 100

Marked-up Copy

-- CLAIM 1 --

3. Encoding method according to one of the claims 1 and 2, characterized in that it enables access to several levels of encoding quality, corresponding to each of said successive meshes.

-- CLAIM 1 --

4. Encoding method according to any of the claims 1 to 3, characterized in that said successive meshes are obtained by the implementation of a recursive algorithm.

-- CLAIM 1 --

5. Encoding method according to any of the claims 1 to 4, characterized in that said recursive algorithm comprises the following steps:

- (a) the reception (31) of a wavelet coefficient indexed by a vertex (s) of barycentric coordinates (α, β, γ) on a face F_0 ;
- (b) for each neighboring face F_j of F_0 containing said vertices (s):
 - $F = F_i$ is supposed;
 - from the barycentric coordinates (α, β, γ) , the coordinates of said vertex (s) in the refined base (42) formed by the vertices of the face F , also referenced (α, β, γ) are deduced;
 - if the coordinates α , β or γ are positive or zero and if two of them are strictly positive (43):
 - the face F (45) is subdivided;
 - the processing of the step (b) is resumed for the four offspring of the face F successively

- - CLAIM 1 - -

8. Application of the encoding method according to [any of the claims 1 to 5] to at least one of the following fields:

- the display of meshed objects in a 3D screen;
- the progressive display of meshed objects in three dimensions on a screen, said wavelet coefficients being taken into account as and when they arrive;
- the display of meshed objects in three dimensions on a screen with at least two levels of detail, one level of detail corresponding to one of said successive meshes (M_i);
- the display of different parts of a meshed object with at least two different levels of detail;
- the compression of a mesh of a meshed object.

SELECTIVE MESH REFINEMENT

The field of the invention is that of the encoding of images or image elements. More specifically, the invention relates to the adaptive representation and encoding of scenes (or objects of a scene) in three dimensions (3D) represented by meshes.

The invention can be applied in all fields where it is desirable to reduce the number of information elements needed for the efficient depiction, storage and/or transmission of a digital image. For example, the invention may be used to transmit images through the Internet. In this context, it enables the animation of 3D scenes with real-time display although the bit rate is neither constant nor ensured. In this case, the invention may be a primitive of a data transmission language such as VRML.

Other applications that may be envisaged include the storage of animated data on CD-ROM (or an equivalent data carrier), multiple-user applications, digital television, etc.

The invention proposes an improvement to so-called "wavelet" methods used to represent a mesh as a sequence of details added to a basic mesh. The general theory of this technique is described especially in the article by M. Lounsberry, T. DeRose and J. Warren, "Multiresolution analysis for surfaces or arbitrary topological type" (ACM Transaction on Graphics, Vol. 16, No. 1, pp. 34-73).

According to this technique, a mesh is therefore represented by a sequence of coefficients that correspond to the coordinates in a base of wavelets of a parametrization of said mesh by a simple polyhedron. The corresponding mathematical principles are recalled in the appendix (this appendix forms part of the present description).

In practice, during the reconstruction, the basic mesh M_0 is shown in tree form: each of its faces is the root of a tree for which the offspring of each node are the four faces obtained after canonical subdivision. The wavelet coefficients are indexed by their barycentric coordinates on one face of M_0 .

A subdivision technique has been proposed by A. Certain, Jovan Popovic, T. DeRose, T. Duchamp, D. Salesin and W. Stuetzle in the article "Interactive Multiresolution Surface Viewing" (Computer Graphics Proceedings 1996).

5 This technique consists in making subdivisions by observing a sufficient condition on the vertices: a vertex is said to be full if it is in the middle of a ridge shared by two faces that are subdivided into four as shown in Figure 1.

10 The principle lies in starting from the vertex indexing the wavelet coefficient considered and, by subdivision, making its neighbors and then the neighbors of its neighbors complete, recursively until all the vertices are considered to be complete. This rule is derived from the observation that this algorithm is sufficient to provide for a subdivision adapted to the modifications made by the wavelet coefficient considered.

15 However, this technique has a major drawback: it induces the creation of unnecessary facets, leading to an unnecessary increase in the number of data elements necessary for the description of the mesh. More specifically, unnecessary facets are created by subdivisions that give the completeness of the vertices referred to further above.

20 In other words, there is a creation, in zones relatively distant from the support of the observed wavelet, of coplanar facets. This unnecessarily lowers the efficiency of the display of the object.

It is indeed known that the number of data elements (and therefore the number of facets) has major consequences especially when the object concerned is animated, the power of the terminal is limited and/or the transmission bit rate is variable and/or limited.

25 It is an aim of the invention especially to overcome these drawbacks of the prior art.

30 More specifically, it is an aim of the invention to provide a method for the encoding of a mesh representing a 3D object that produces a number of facets that is limited, as compared with the prior art, for an identical or similar quality of restitution.

Another aim of the invention is to provide an encoding method of this kind whose complexity (especially in terms of numbers of operations performed and memory capacity needed) is smaller, or at least of the same magnitude, as that of the known techniques.

5 It is also an aim of the invention to provide an encoding method of this kind, that can be used to have several levels of quality of restitution of the object, as a function of various criteria (processing capacity of the terminal, capacity of the available storage means, transmission bit rate, the user's needs, etc.).

10 Yet another aim of the invention is to provide an encoding method of this kind that can be used for a progressive reconstruction of the object.

It is also an aim of the invention, naturally, to provide a method of reconstruction of an object encoded according to this encoding method.

15 These aims and others that shall appear hereinafter are achieved according to the invention by means of a method for the encoding of a source mesh (M) representing a 3D object in which there is determined a simple mesh (M_0) with a limited number of faces, each defined by vertices and ridges, and then coefficients in a base of wavelets of a function (f), of which said source mesh is the image defined on said simple mesh (M_0), so as to give a subdivision of said source mesh (M) into successive refined meshes (or sub-meshes) (M_j), according to a
20 predetermined criterion. According to the invention, each of the faces of said meshes (M_j) is subdivided into a limited number of facets to form the higher-level mesh (M_{j+1}), the subdivisions of said face corresponding solely to those needed to comply with a condition of affinity of said function (f) on said face.

25 Indeed, the inventor has observed that the taking into account of a wavelet coefficient must be accompanied by a local subdivision in the vicinity of the vertex indexing the wavelet in question, so that this wavelet can be refined by pieces on said facet. Since, the wavelets are the sums of functions ϕ_i^j , it is sufficient to be able to localize the support of such a function and locally subdivide the facets that contain them until this function is refined on each
30 resultant facet.

It will be noted hereinafter that the terms "face" and "facet" are used without distinction. In general, a "facet" is a subdivision of a "face".

Advantageously, said source mesh (M) is subdivided up into a set of trees, each of said trees representing a face of said simple mesh (M_0) and comprising
 5 nodes each representing a face of a mesh (M_j), said function (f) being refined on each of said faces. Then, each of said trees is the smallest such that, when a given face is subdivided into four facets, the corresponding node comprises four offspring representing said four facets.

Advantageously, the method of the invention enables access to several
 10 levels of encoding quality, corresponding to each of said successive meshes.

This is easy because of the very structure of the subdivision as shall be seen hereinafter.

Preferably, said successive meshes are obtained by the implementation of a recursive algorithm. The method is thus particularly simple to implement.

15 According to an advantageous embodiment, said recursive algorithm comprises the following steps:

- (a) the reception of a wavelet coefficient indexed by a vertex (s) of barycentric coordinates (α, β, γ) on a face F_0 ;
- (b) for each neighboring face F_j of F_0 containing said vertices (s):
 20 - $F = F_i$ is supposed;
 - from the barycentric coordinates (α, β, γ) , the coordinates of said vertex (s) in the refined base formed by the vertices of the face F, also referenced (α, β, γ) , are deduced ;
 - if the coordinates α, β or γ are positive or zero and if two of
 25 them are strictly positive:
 - the face F is subdivided;
 - the processing of the step (b) is resumed for the four offspring of the face F successively.

The invention also relates to a method of reconstruction of a source mesh (M) representing a 3D object encoded according to the encoding method described here above.

Advantageously, a method of reconstruction of this kind provides for the
 5 progressive reconstruction of said object using the simple mesh (M_0) and then by means of successive meshes (M_i).

Preferably, this method of reconstruction enables access to several levels of quality of encoding, corresponding to each of said successive meshes.

The invention can be applied advantageously to several fields and can be
 10 applied especially to at least one of the following fields:

- the display of meshed objects in a 3D screen;
- the progressive display of meshed objects in three dimensions on a screen, said wavelet coefficients being taken into account as and when they arrive;
- 15 - the display of meshed objects in three dimensions on a screen with at least two levels of detail, one level of detail corresponding to one of said successive meshes (M_i);
- the display of different parts of a meshed object with at least two different levels of detail;
- 20 - the compression of a mesh of a meshed object.

Other features and advantages of the invention shall appear more clearly from the following description of a preferred embodiment of the invention given by way of a simple non-restrictive illustration and from the appended drawings, of which:

- 25 - Figure 1, already commented upon in the introduction, illustrates a complete vertex according to the technique used by Certain et al.;
- Figure 2 illustrates the direct neighborhood of a vertex s according to the invention;
- Figure 3 is a simplified general block diagram of the encoding method
 30 according to the invention;

- Figure 4 is a more detailed block diagram, resuming and detailing the steps of localization and subdivision of Figure 3.

The method of encoding a mesh according to the invention is therefore aimed especially at carrying out the minimum number of subdivisions needed while at the same time retaining the same algorithmic complexity as in the prior art.

Throughout the rest of this document, it will be said that a point s has barycentric coordinates (α, β, γ) , on a face F_0 if its barycentric coordinates in the refined base formed by the vertices of F_0 are (α, β, γ) . Also, M_0 will not be specified when there is no possible confusion.

The basic algorithm of the invention, independently of any implementation, is the following:

1. Receive a wavelet coefficient indexed by a vertex s having barycentric coordinates (α, β, γ) , on a face F_0 .
2. For each neighboring face F_i of F_0 containing s :
 - (a) $F = F_i$.
 - (b) Deduce (α, β, γ) the coordinates of s in the refined base formed by the vertices of F also referenced (α, β, γ) .
 - (c) If α or β or γ are all positive or null or if two of them are strictly positive:
 - i. subdivide F
 - ii. start again at (b) with, for F , its four offspring successively.

When the algorithm stops, there is a minimum subdivision of M_0 obtained with a complexity in linear time as compared with the degree of subdivision. The transmission bit rate and/or the storage capacity needed are therefore optimized.

It must be noted that the invention is used to determine not only the minimum tree corresponding to f , but also each of its approximations, in truncating the sum (see appendix):

$$f = \sum_i c_i^0 \phi_i^0 + \sum_{j \geq 0} \sum_i d_i^j \psi_i^j$$

Since the sum is precisely obtained progressively, by adding terms one after the other, the operation passes from a tree representing an approximation f_i to a tree representing:

$$f_i + c_i^j \psi_i^j$$

(where c_i^j is a wavelet coefficient transmitted in performing only the facet subdivisions strictly necessary for the condition of affinity on each face.

It is thus possible to progressively reconstruct the object and/or to choose a level of quality (corresponding to the index j).

The progressively reconstructed mesh can be represented as n 4-trees describing the successive divisions of the n faces of the mesh M_0 transmitted prior to the wavelet coefficients. Each wavelet coefficient received is accompanied by three integers A , B and C proportional to the barycentric coordinates of the vertex s indexing the wavelet associated with the coefficient, as well as an integer designating the face F_0 indicating a facet containing s .

If s belongs to M_{j+1} , A , B and C are deduced from the barycentric coordinates α, β and γ of s in the refined base formed by the vertices of F_0 by:

$$(A, B, C) = 2^{j+1} (\alpha, \beta, \gamma)$$

The wavelet centered at s has the form:

$$\psi_i^j = \phi_i^{j+1} + \sum_{k \in D} \alpha_k \phi_k^j$$

where D is the neighborhood of s on the mesh M_j . The technique explained in the previous part must therefore be applied to each of the functions that appear in the sum, with their respective barycentric coordinates.

These barycentric coordinates are expressed in the same refined base as those of s and deduced from these coordinates: the neighborhood D is, for a value

of k that is fixed, the set of vertices of M_j at a distance of at most k ridges from one of the ends s_1 and s_2 of the ridge of M_j containing s , as shown in Figure 2. The barycentric coordinates of these two vertices are characterized by the following criterion:

- 5 The triplet $(\alpha', \beta', \gamma')$ represents the coordinates of one of these two points if and only if the triplet of integers $(A', B', C') = 2^j(\alpha', \beta', \gamma')$ verifies:

$$(2A' - A, 2B' - B, 2C' - C) \in \varepsilon$$

where ε designates the set:

10

$$\{(1, -1, 0), (-1, 1, 0), (1, 0, 1), (-1, 0, 1), (0, 1, -1), (0, -1, 1)\}$$

With these two direct neighbors of s , s_1 and s_2 being determined, the others are determined by applying the following criterion k times:

- 15 let u and v be two vertices with barycentric coordinates $(\alpha', \beta', \gamma')$ and $(\alpha'', \beta'', \gamma'')$ respectively on a face F . Then u and v are connected by a ridge on M_j if and only if:

$$2^j(\alpha' - \alpha'', \beta' - \beta'', \gamma' - \gamma'') \in \varepsilon$$

- 20 giving explicitly the list of the vertices in the neighborhood D .

Each of these vertices, provided with its barycentric coordinates (α, β, γ) may thus give rise to the subdivisions needed for the modifications made by the corresponding function ϕ , according to a variant of the algorithm described further above. The operation starts from the pair $(A, B, C) = 2^j(\alpha, \beta, \gamma)$ where j is the smallest integer such that A, B and C are integers and, at each subdivision, the basic change matrix of this triplet is applied in such a way that tests of positivity are made only on the integers.

25 The four matrices of passage of the refined base represented by the three vertices of a face with refined bases represented by the three vertices of each of the offspring are explicitly:

30

$$\begin{pmatrix} 1 & -1 & -1 \\ 0 & 2 & 0 \\ 0 & 1 & 2 \end{pmatrix}, \begin{pmatrix} 2 & 0 & 0 \\ -1 & 1 & -1 \\ 0 & 0 & 2 \end{pmatrix}, \begin{pmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ -1 & -1 & 1 \end{pmatrix} \text{ et } \begin{pmatrix} 1 & 1 & -1 \\ -1 & 1 & 1 \\ 1 & -1 & 1 \end{pmatrix}$$

5 The method described here above is illustrated in a very simplified way in Figure 3. For each wavelet coefficient D_i^j received (31), a localization step 32 is performed in which the elements to be processed are brought into the appropriate refined base and then a step of subdivision (33) of each face considered is performed.

10 A more detailed exemplary implementation of these two steps 32 and 33 is shown in Figure 4.

In the localization 32, with ψ_i^j being written as a weighted sum of scale functions at the level $j+1$, the faces and the barycentric coordinates of the points of M_0 (or vertices of M_j) indexing these scale functions are determined.

15 Then, for each triplet with coordinates (α, β, γ) associated with a face F (41), the coordinates $(\alpha', \beta', \gamma')$ corresponding to (α, β, γ) in the base of the vertices of F are computed (42) and $(\alpha, \beta, \gamma) = (\alpha', \beta', \gamma')$ is supposed.

Then the test 43 is performed:

$$(\alpha \geq 0) \text{ and } (\beta \geq 0) \text{ and } (\gamma \geq 0) \text{ and } ((\alpha \beta > 0) \text{ or } (\alpha \gamma > 0) \text{ or } (\beta \gamma > 0))$$

20 If the result is positive (44), a recursivity loop is made in which the face F is subdivided (45) into four offspring F_i and then for each offspring F_i (46) $F = F_i$ (47) is supposed and the operation is resumed at the step 41 recursively.

If the result of the test 43 is negative, the processing is resumed (48) for a new face F (41). When all the faces F have been processed, the subdivision is ended (49).

APPENDIX

A surface S in the space may be represented as the image of a continuous injective function defined on a polyhedron M_0 of the topological type with values in \mathbf{R}^3 . It is said then that the surface is parametrized by the polyhedron, and it is called the parametrization of said function. This function is a triplet of functions whose values in \mathbf{R} , each of which may each be developed in a base of the space $C^0(M_0)$ of the continuous functions on the polyhedrons with values in \mathbf{R} .

In the case of the meshed surfaces, this technique is used to obtain a compressed mesh representation. Furthermore, the use of wavelets as a basic function provides for a progressive representation thereof from the roughest form to the most detailed form.

These function are not wavelets in the standard sense but are in accordance with refining relationships that generalize the concept of multiple resolution analysis. Let M_0 denote a polyhedron on which a parametrization of a surface M is defined. We consider the subspace S_0 of $C^0(M_0)$ generated by the functions ϕ_i^0 , defined as follows: ϕ_i^0 is refined on each facet, equals 1 on the i -th vertex and equals 0 on all the other vertices.

The subspaces S_j engendered by the functions ϕ_i^j are defined in the same way but in replacing M_0 by the mesh M_j obtained by canonically subdividing each facet of M_{j-1} . The spaces S_j are finite in dimension and nested, S_0 being the smallest and every continuous function of M_0 in \mathbf{R} can be approached uniformly by a function of an S_j for j as a fairly large number.

It is this inclusion that enables the progressive encoding: if W_j is taken to denote an additional value of S_j and S_{j+1} and $\{\psi_i^j\}^i$ (the wavelets) a base of W_j , the set

$$\{\phi_i^0\}_i \cup \bigcup_{j \geq 0} \{\psi_i^j\}_i$$

forms a base of $C^0(M_0)$. The function ρ parametrizing M is written therefore in a unique way:

$$\rho = \sum_i c_i \phi_i^0 + \sum_{j \geq 0} \sum_i d_i^j \psi_i^j,$$

where the values c_i and the values d_i^j are in \mathbf{R}^3 , and are called wavelet coefficients.

- 5 In practice, the wavelets are chosen in such a way that their support enables a determining of the coefficients of wavelets at $O(n)$ where n is the number of vertices of the mesh M : for k as a fixed integer, if $D_{k,i}$ is taken to denote the set of indices of the vertices of a mesh M_j which are at a distance of less than k ridges from the vertex i , the wavelet ψ_i^j is given by:

10

$$\psi_i^j = \phi_i^{j+1} + \sum_{l \in D_{k,i}} \alpha_l \phi_l^j,$$

in such a way that ψ_i^j is with a support in $D_{k+1,i}$.

- 15 Thus, during the reconstruction, the influence of a wavelet coefficient is limited to a neighborhood of this kind.

CLAIMS :

1. Method for the encoding of a source mesh (M) representing a 3D object in which there is determined a simple mesh (M_0) with a limited number of faces, each defined by vertices and ridges, and then coefficients in a base of wavelets of a function (f) of which said source mesh is the image defined on said simple mesh (M_0), so as to give a subdivision of said source mesh (M) into successive refined meshes (or sub-meshes) (M_j), according to a predetermined criterion. characterized in that each of the faces of said meshes (M_j) is subdivided into a limited number of facets to form the higher-level mesh (M_{j+1}), the subdivisions of said face corresponding solely to those needed to comply with a condition of affinity of said function (f) on said face.

2. Encoding method according to claim 1, characterized in that said source mesh (M) is subdivided up into a set of trees, each of said trees representing a face of said simple mesh (M_0) and comprising nodes each representing a face of a mesh (M_j), said function (f) being refined on each of said faces and each of said trees being the smallest such that, when a given face is subdivided into four facets, the corresponding node comprises four offspring representing said four facets.

3. Encoding method according to one of the claims 1 and 2, characterized in that it enables access to several levels of encoding quality, corresponding to each of said successive meshes.

4. Encoding method according to any of the claims 1 to 3, characterized in that said successive meshes are obtained by the implementation of a recursive algorithm.

5. Encoding method according to any of the claims 1 to 4, characterized in that said recursive algorithm comprises the following steps:

- (a) the reception (31) of a wavelet coefficient indexed by a vertex (s) of barycentric coordinates (α, β, γ) on a face F_0 ;
- (b) for each neighboring face F_j of F_0 containing said vertices (s):

- $F = F_i$ is supposed;
- from the barycentric coordinates (α, β, γ) , the coordinates of said vertex (s) in the refined base (42) formed by the vertices of the face F, also referenced (α, β, γ) are deduced;
- if the coordinates α , β or γ are positive or zero and if two of them are strictly positive (43):
 - the face F (45) is subdivided;
 - the processing of the step (b) is resumed for the four offspring of the face F successively.

6. Method of reconstruction of a source mesh (M) representing a 3D object encoded according to the encoding method of claim 1, characterized in that said object is reconstructed progressively, using the simple mesh (M_0), and then by means of successive meshes (M_i).

7. Method of reconstruction according to claim 6, characterized in that it enables access to several levels of quality of encoding, corresponding to each of said successive meshes.

8. Application of the encoding method according to any of the claims 1 to 5 to at least one of the following fields:

- the display of meshed objects in a 3D screen;
- the progressive display of meshed objects in three dimensions on a screen, said wavelet coefficients being taken into account as and when they arrive;
- the display of meshed objects in three dimensions on a screen with at least two levels of detail, one level of detail corresponding to one of said successive meshes (M_i);
- the display of different parts of a meshed object with at least two different levels of detail;
- the compression of a mesh of a meshed object.

LEGENDES DES DESSINS

Figure 3 ;

- 5 31. Reception of a wavelet coefficient d_i
32. Localization
33. Subdivision

Figure 4

10

Reprendre les légendes telles que traduites par le WPO sauf la référence 33 :
remplacer « peak » par « vertex ».

1/2

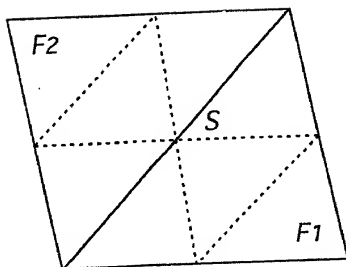


Fig. 1

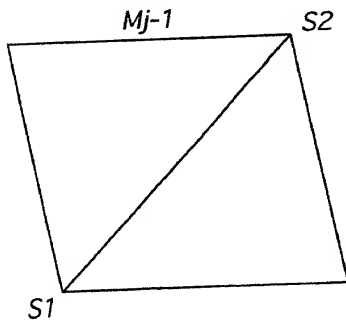
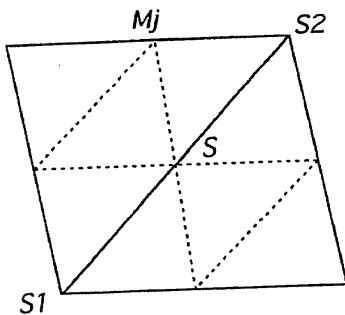


Fig. 2

2/2

Fig. 3

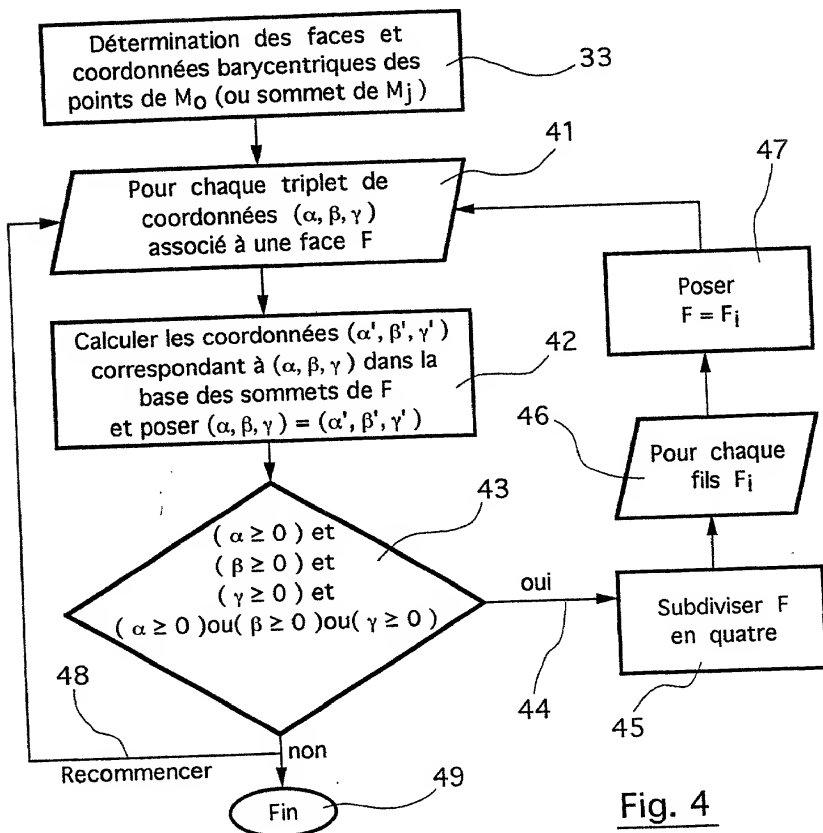
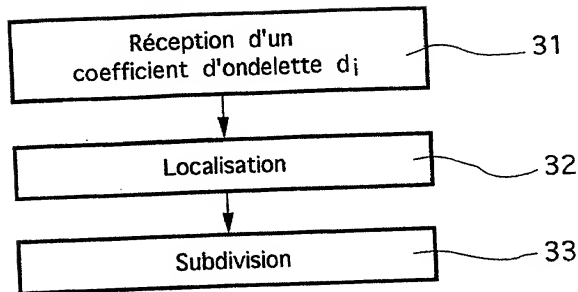


Fig. 4

MERCHANT & GOULD P.C.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a joint named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name, as:

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: SELECTIVE MESH REFINEMENT

The specification of which

- a. ☐ is attached hereto
 b. ☒ was filed on January 17, 2001 as application serial no. and was amended on (if applicable) (in the case of a PCT-filed application) described and claimed in international no. PCT/FR99/01924 filed August 3, 1999 and as amended on (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

- a. ☐ no such applications have been filed.
 b. ☒ such applications have been filed as follows:

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)
France	98 10097	August 3, 1998	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

U.S. PROVISIONAL APPLICATION NUMBER	DATE OF FILING (Day, Month, Year)

I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (reprinted below):

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim;

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

(e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W.	Reg. No. 40,481	Leon, Andrew J.	Reg. No. 46,869
Ali, M. Jeffer	Reg. No. 46,359	Leonard, Christopher J.	Reg. No. 41,940
Anderson, Gregg I.	Reg. No. 28,828	Liepa, Mara E.	Reg. No. 40,066
Batzli, Brian H.	Reg. No. 32,960	Lindquist, Timothy A.	Reg. No. 40,701
Beard, John L.	Reg. No. 27,612	Lycke, Lawrence E.	Reg. No. 38,540
Berns, John M.	Reg. No. 43,496	Mayfield, Denise L.	Reg. No. 33,732
Black, Bruce E.	Reg. No. 41,622	McDonald, Daniel W.	Reg. No. 32,044
Branch, John W.	Reg. No. 41,633	McIntyre, Jr., William F.	Reg. No. 44,921
Bremer, Dennis C.	Reg. No. 40,528	Mitchem, M. Todd	Reg. No. 40,731
Bruess, Steven C.	Reg. No. 34,130	Mueller, Douglas P.	Reg. No. 30,300
Byrne, Linda M.	Reg. No. 32,404	Nichols, A. Shane	Reg. No. 43,836
Campbell, Keith	Reg. No. P-46,597	Pauly, Daniel M.	Reg. No. 40,123
Carlson, Alan G.	Reg. No. 25,959	Phillips, Bryan K.	Reg. No. P-46,990
Caspers, Philip P.	Reg. No. 33,227	Phillips, John B.	Reg. No. 37,206
Chiapetta, James R.	Reg. No. 39,634	Prendergast, Paul	Reg. No. 46,068
Clifford, John A.	Reg. No. 30,247	Pytel, Melissa J.	Reg. No. 41,512
Coldren, Richard J.	Reg. No. 44,084	Qualey, Terry	Reg. No. 25,148
Daignault, Ronald A.	Reg. No. 25,968	Reich, John C.	Reg. No. 37,703
Daley, Dennis R.	Reg. No. 34,994	Reiland, Earl D.	Reg. No. 25,767
Dalglish, Leslie E.	Reg. No. 40,579	Samuels, Lisa A.	Reg. No. 43,080
Daulton, Julie R.	Reg. No. 36,414	Schmaltz, David G.	Reg. No. 39,828
DeVries Smith, Katherine M.	Reg. No. 42,157	Schuman, Mark D.	Reg. No. 31,197
DiPietro, Mark J.	Reg. No. 28,707	Schumann, Michael D.	Reg. No. 30,422
Edell, Robert T.	Reg. No. 20,187	Scull, Timothy B.	Reg. No. 42,137
Epp Ryan, Sandra	Reg. No. 39,667	Sebald, Gregory A.	Reg. No. 33,280
Glance, Robert J.	Reg. No. 40,620	Skoog, Mark T.	Reg. No. 40,178
Goggins, Matthew J.	Reg. No. 44,125	Spellman, Steven J.	Reg. No. 45,124
Golia, Charles E.	Reg. No. 26,896	Stoll-DeBell, Kirstin L.	Reg. No. 43,164
Gorman, Alan G.	Reg. No. 38,472	Sumner, John P.	Reg. No. 29,114
Gould, John D.	Reg. No. 18,223	Swenson, Erik G.	Reg. No. 45,147
Gregson, Richard	Reg. No. 41,804	Tellekson, David K.	Reg. No. 32,314
Gresens, John J.	Reg. No. 33,112	Trembath, Jon R.	Reg. No. 38,344
Hammer, Samuel A.	Reg. No. 46,754	Tuchman, Ido	Reg. No. 45,924
Hammer, Curtis B.	Reg. No. 29,165	Tunheim, Marcia A	Reg. No. 42,189
Harrison, Kevin C.	Reg. No. P-46,759	Underhill, Albert L.	Reg. No. 27,403
Hertzberg, Brett A.	Reg. No. 42,660	Vandenburgh, J. Derek	Reg. No. 32,179
Hillson, Randall A.	Reg. No. 31,838	Wahl, John R.	Reg. No. 33,044
Holzer, Jr., Richard J.	Reg. No. 42,668	Weaver, Karrie G.	Reg. No. 43,245
Johnston, Scott W.	Reg. No. 39,721	Welter, Paul A.	Reg. No. 20,890
Kadievitch, Natalie D.	Reg. No. 34,196	Whippes, Brian	Reg. No. 43,261
Karjeker, Shaukat	Reg. No. 34,049	Whitaker, John E.	Reg. No. 42,222
Kastelic, Joseph M.	Reg. No. 37,160	Wickhem, J. Scot	Reg. No. 41,376
Kettelberger, Denise	Reg. No. 33,924	Williams, Douglas J.	Reg. No. 27,054
Keys, Jeramie J.	Reg. No. 42,724	Withers, James D.	Reg. No. 40,376
Knearl, Homer L.	Reg. No. 21,197	Witt, Jonelle	Reg. No. 41,980
Kowalchuk, Alan W.	Reg. No. 31,535	Wu, Tong	Reg. No. 43,361
Kowalchuk, Katherine M.	Reg. No. 36,848	Xu, Min S.	Reg. No. 39,536
Lacy, Paul E.	Reg. No. 38,946	Zeuli, Anthony R.	Reg. No. 45,255
Larson, James A.	Reg. No. 40,443		

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould P.C. to the contrary.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below:

Merchant & Gould P.C.
P.O. Box 2903
Minneapolis, MN 55402-0903



23552

PATENT TRADEMARK OFFICE

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2	Full Name Of Inventor	Family Name Gioia	First Given Name Patrick	Second Given Name
0	Residence & Citizenship	City Rennes	State or Foreign Country France <i>FR</i>	Country of Citizenship France
1	Mailing Address	Address 32, rue Mirabeau 35 K	City Rennes	State & Zip Code/Country 35700 / France
Signature of Inventor 201:			Date: <i>02/02/02</i>	

MERCHANT & GOULD P.C.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: SELECTIVE MESH REFINEMENT

The specification of which

- a. ☐ is attached hereto
b. ☒ was filed on as application serial no. and was amended on (if applicable) (in the case of a PCT-filed application) described and claimed in international no. PCT/FR99/01924 filed August 3, 1999 and as amended on (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

- a. ☐ no such applications have been filed.
b. ☒ such applications have been filed as follows:

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)
France	98 10097	August 3, 1998	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

U.S. PROVISIONAL APPLICATION NUMBER	DATE OF FILING (Day, Month, Year)

I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (reprinted below):

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a *prima facie* case of unpatentability of a claim;

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A *prima facie* case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

(e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W. Reg. No. 40,481
 Ali, M. Jeffier Reg. No. 46,359
 Anderson, Gregg I. Reg. No. 28,828
 Batzli, Brian H. Reg. No. 32,960
 Beard, John L. Reg. No. 27,612
 Berns, John M. Reg. No. 43,496
 Black, Bruce E. Reg. No. 41,622
 Branch, John W. Reg. No. 41,633
 Bremer, Dennis C. Reg. No. 40,528
 Bruess, Steven C. Reg. No. 34,130
 Byrne, Linda M. Reg. No. 32,404
 Campbell, Keith Reg. No. P-46,597
 Carlson, Alan G. Reg. No. 25,959
 Caspers, Philip P. Reg. No. 33,227
 Chiapetta, James R. Reg. No. 39,634
 Clifford, John A. Reg. No. 30,247
 Coldren, Richard J. Reg. No. 44,084
 Daignault, Ronald A. Reg. No. 25,968
 Daley, Dennis R. Reg. No. 34,994
 Dalglish, Leslie E. Reg. No. 40,579
 Daulton, Julie R. Reg. No. 36,414
 DeVries Smith, Katherine M. Reg. No. 42,157
 DiPietro, Mark J. Reg. No. 28,707
 Edell, Robert T. Reg. No. 20,187
 Epp Ryan, Sandra Reg. No. 39,667
 Glance, Robert J. Reg. No. 40,620
 Goggins, Matthew J. Reg. No. 44,125
 Golla, Charles E. Reg. No. 26,896
 Gorman, Alan G. Reg. No. 38,472
 Gould, John D. Reg. No. 18,223
 Gregson, Richard Reg. No. 41,804
 Gresens, John J. Reg. No. 33,112
 Hamer, Samuel A. Reg. No. 46,754
 Hamre, Curtis B. Reg. No. 29,165
 Harrison, Kevin C. Reg. No. P-46,759
 Hertzberg, Brett A. Reg. No. 42,660
 Hillson, Randall A. Reg. No. 31,838
 Holzer, Jr., Richard J. Reg. No. 42,668
 Johnston, Scott W. Reg. No. 39,721
 Kadievitch, Natalie D. Reg. No. 34,196
 Karjeker, Shaukat Reg. No. 34,049
 Kastelic, Joseph M. Reg. No. 37,160
 Kettelberger, Denise Reg. No. 33,924
 Keys, Jeramie J. Reg. No. 42,724
 Knearl, Homer L. Reg. No. 21,197
 Kowalchuk, Alan W. Reg. No. 31,535
 Kowalchuk, Katherine M. Reg. No. 36,848
 Lacy, Paul E. Reg. No. 38,946
 Larson, James A. Reg. No. 40,443

Leon, Andrew J. Reg. No. 46,869
 Leonard, Christopher J. Reg. No. 41,940
 Liepa, Mara E. Reg. No. 40,066
 Lindquist, Timothy A. Reg. No. 40,701
 Lycke, Lawrence E. Reg. No. 38,540
 Mayfield, Denise L. Reg. No. 33,732
 McDonald, Daniel W. Reg. No. 32,044
 McIntyre, Jr., William F. Reg. No. 44,921
 Mitchem, M. Todd Reg. No. 40,731
 Mueller, Douglas P. Reg. No. 30,300
 Nichols, A. Shane Reg. No. 43,836
 Pauly, Daniel M. Reg. No. 40,123
 Phillips, Bryan K. Reg. No. P-46,990
 Phillips, John B. Reg. No. 37,206
 Prendergast, Paul Reg. No. 46,068
 Pytel, Melissa J. Reg. No. 41,512
 Qualey, Terry Reg. No. 25,148
 Reich, John C. Reg. No. 37,703
 Reiland, Earl D. Reg. No. 25,767
 Samuels, Lisa A. Reg. No. 43,080
 Schmaltz, David G. Reg. No. 39,828
 Schuman, Mark D. Reg. No. 31,197
 Schumann, Michael D. Reg. No. 30,422
 Scull, Timothy B. Reg. No. 42,137
 Sebald, Gregory A. Reg. No. 33,280
 Skoog, Mark T. Reg. No. 40,178
 Spellman, Steven J. Reg. No. 45,124
 Stoll-DeBell, Kirstin L. Reg. No. 43,164
 Sumner, John P. Reg. No. 29,114
 Swenson, Erik G. Reg. No. 45,147
 Telleson, David K. Reg. No. 32,314
 Trembath, Jon R. Reg. No. 38,344
 Tuchman, Ido Reg. No. 45,924
 Tunheim, Marcia A. Reg. No. 42,189
 Underhill, Albert L. Reg. No. 27,403
 Vandenburgh, J. Derek Reg. No. 32,179
 Wahl, John R. Reg. No. 33,044
 Weaver, Karrie G. Reg. No. 43,245
 Welter, Paul A. Reg. No. 20,890
 Whipps, Brian Reg. No. 43,261
 Whitaker, John E. Reg. No. 42,222
 Wickham, J. Scot Reg. No. 41,376
 Williams, Douglas J. Reg. No. 27,054
 Withers, James D. Reg. No. 40,376
 Witt, Jonelle Reg. No. 41,980
 Wu, Tong Reg. No. 43,361
 Xu, Min S. Reg. No. 39,536
 Zeuli, Anthony R. Reg. No. 45,255

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould P.C. to the contrary.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below:

Merchant & Gould P.C.
 P.O. Box 2903
 Minneapolis, MN 55402-0903



I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2	Full Name Of Inventor	Family Name Gioia	First Given Name Patrick	Second Given Name
0	Residence & Citizenship	City Rennes	State or Foreign Country France	Country of Citizenship France
1	Mailing Address	Address 32, rue Mirabeau 336 K	City Rennes	State & Zip Code/Country 35700 / France
Signature of Inventor 201:			Date:	

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2